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IS 11283 (1985): Determination of softening point of iron
oxides (in powder form):lump ore,sinterand pellets [MTD 13:
Ores and Raw Materials]
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"ज्ञान से एक नये भारत का निर्माण"
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Bhartṛhari—Nītiśatakam
"Knowledge is such a treasure which cannot be stolen"

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Indian Standard

METHOD FOR
DETERMINATION OF SOFTENING POINT
OF IRON OXIDES (IN POWDER FORM);
LUMP ORE, SINTER AND PELLETS

UDC   669·173·2 : 536·421·2

Indian Standard

METHOD FOR DETERMINATION OF SOFTENING POINT OF IRON OXIDES (IN POWDER FORM); LUMP ORE, SINTER AND PELLETS

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2

Indian Standard

METHOD FOR
DETERMINATION OF SOFTENING POINT
OF IRON OXIDES (IN POWDER FORM);
LUMP ORE, SINTER AND PELLETS

0. F O R E W O R D

0.1 This Indian Standard was adopted by the Indian Standards Institution on 30 May 1985, after the draft finalized by the Ores and Raw Materials Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 The increasing importance of the cohesive zone in blast furnace iron making in controlling the quality of hot metal and productivity of blast furnaces has recently become abundantly clear. One of the important characteristics governing geometry of the cohesive zone is the softening characteristics of the iron oxide feed. This standard attempts to propose a standard method for determining the softening characteristics of iron oxides (in powder form); lump ore, sinter and pellets.

0.3 It is to be noted that in this text all the iron oxides are crushed to a fine size in order to make a relative assessment of all three types of oxide feeds. In the case of IS : 9660-1980* applicable only to pellets, a feed of 9 to 16 mm, covering almost the entire range of pellets actually used in blast furnaces, are tested. The two standards are thus complementry.

0.4 This method is based on the method evolved at CRM laboratories, Belgium.

0.5 In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960†

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*Guidelines for determination of softening characteristics of iron ore pellets.
†Rules for rounding off numerical values (*revised*).

1. SCOPE

1.1 This standard prescribes the method for the determination of softening point of iron oxides (in powder form); lump ore, sinter and pellets.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 Softening Start Temperature — It is a temperature at which 3 percent contraction in the initial bed height occurs instead of continuing the test till the material is fully molten.

2.2 Softening Finish Temperature — It is a temperature at which 10 percent contraction in the initial bed height occurs instead of continuing the test till the material is fully molten.

3. PRINCIPLE OF TEST

3.1 For a bed of given height of any solid material when heated, the height of the bed initially increases because of thermal expansion. This behaviour continues with increasing temperature till a point is reached when the solid starts softening. At this temperature, the expansion tendency of the bed is more than compensated by the collapse of the bed because of softening and the bed height starts to decrease. With any further rise in temperature, the bed height continues to decrease till the solid is fully molten after which the bed height remains more or less unaltered. This test involves compacting the crucible inside a tubular furnace preheated to a temperature and the plunger and dial gauge are mounted on the sample. The temperature is gradually increased and the dial gauge reading is noted at regular intervals. The test is discontinued when the contraction in the initial bed height reaches a level of 10 percent.

4. NUMBER OF TEST

4.1 The test shall be carried out in duplicate on material in the size range of 1·4 to 2·0 mm.

5. SAMPLES

5.1 The softening point test samples may be taken either from the physical test or pre-reduced to the required degree.

5.2 The total mass of the softening test sample shall be approximately 40 g crushed to a size according to **4.1**.

5.3 The sample shall be placed inside a heat resistant crucible of 30 mm dia compacting by dropping a fixed weight of 6 kg on it three times from a height of 65 mm in order to keep the sample height to 30 mm.

6. HEATING

6.1 After placing the sample in the crucible, it is placed in the furnace, preheated to 800 $\pm$ 10°C. The temperature is increased at the rate of 4°C/min. The heating is continued until the softening finish temperature is reached according to **2.2** and **3.1**.

6.1.1 In case a pre-reduced sample is taken for the test, then heating shall be done under nitrogen atmosphere to avoid oxidation of the sample on heating.

7. PRESSURE APPLIED

7.1 A constant pressure of 2 kg/cm^2 shall be applied throughout the test to the sample by a lever arrangement.

8. APPARATUS

8.1 The softening test apparatus consist of a heat resistant steel crucible with a detachable bottom. The sample is first placed in the crucible and compacted by dropping a fixed weight on it three times. It is ensured that the initial compactness of the bed remains the same in all the tests. The crucible is then suspended inside an electrically heated tubular furnace, preheated to a temperature of 800 $\pm$ 10°C and the sample is exposed to a fixed load applied through a plunger rod. The dilatation and contraction in the bed height of the sample is measured by a dial gauge. A typical arrangement of the apparatus is shown in Fig. 1.

8.2 The crucible shall be made of heat resisting non-scaling steel with a detachable bottom which is pinned to the lower part of the crucible. The crucible is so suspended inside the furnace that the lower part where the sample is kept should lie near the central heating zone of the furnace. A typical illustration of the crucible is shown in Fig. 1.

8.3 Furnace — The furnace shall be an electrically heated tubular type. The uniform rise in temperature should be monitored by an external temperature controller and the furnace shall be capable of raising the temperature up to 1 400°C. The accuracy of the temperature controller shall be $\pm$5°C.

8.4 Dial Gauge — The dial gauge shall be of 0-10 mm with a least count of 0·01 mm.
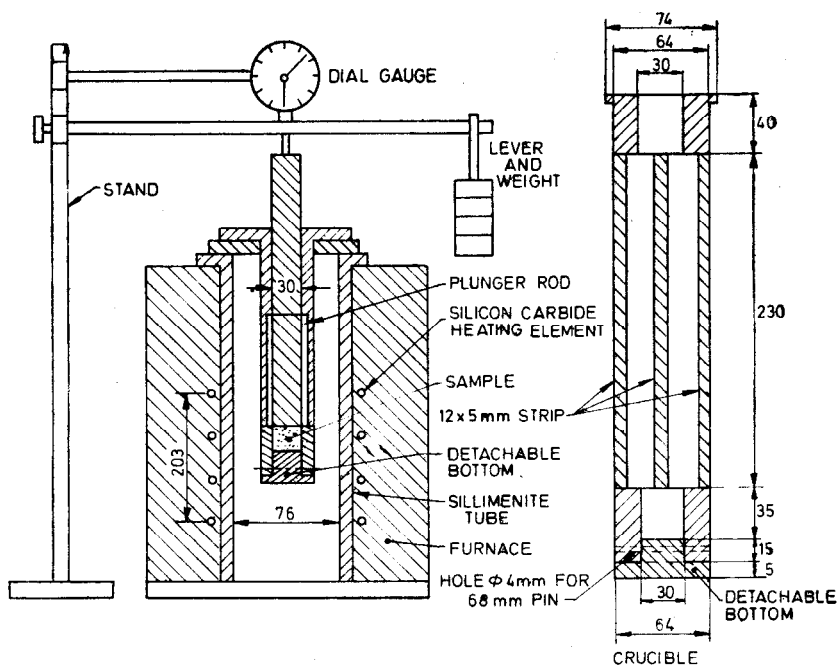
5

FIG. 1 TEST APPARATUS FOR THE DETERMINATION OF SOFTENING
POINT OF IRON ORE, SINTER AND PELLET

8.5 Sieves — 1·4 to 2·00 mm wire sieves conforming to IS : 360 (Part 1)
1978* shall be used.

9. PROCEDURE

9.1 Approximately 40 g of sample should be put into the crucible and
subsequently compacted by means of dropping three times a 6 kg weight
from a height of 65 mm in order to have same initial sample bed height of
30 mm. The plunger rod is then placed on top of the sample. The crucible
and the plunger rod assembly is suspended inside an electrically heated
tubular furnace preheated to 800 ± 10°C. A load of 2 kg/cm² is applied to
the sample through the plunger rod by means of a lever arrangement.
The dial gauge is mounted on the plunger to measure the dilation and
contraction of the bed height.

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*Specification for test sieves: Part 1 Wire cloth test sieves (*second revision*).

6

9.2 After keeping the crucible inside the furnace, the temperature is allowed to stabilize at 800 $\pm$ 10°C, subsequently the temperature of the furnace is raised at the rate of 4°C/min under a nitrogen atmosphere if a pre-reduced sample is taken for the test. The dial gauge reading is noted at regular intervals with every 40°C rise in temperature. The contraction of the bed occurs after the initial expansion with the movement of the dial gauge needle in the opposite direction.

9.3 The test shall be performed until the contraction in the initial bed height reaches a level of 10 percent.
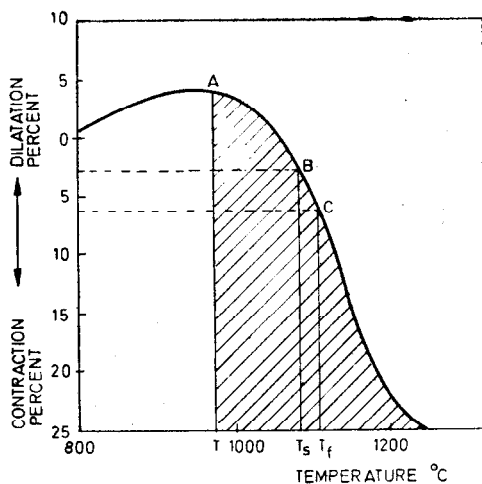
9.4 The softening finish temperature is taken at 10 percent contraction in the initial bed height because at higher degrees of softening, the difficulties are encountered with sticking of the softened material in the crucible.

10. EXPRESSION OF RESULTS

10.1 The following data shall be reported:

a) The softening start temperature (T_s),

b) The softening finish temperature (T_f), and

c) The temperature (T) at which the contraction of the bed begins.

10.2 The reading obtained are plotted as dilatation/contraction on the Y-axis against the temperature on the X-axis. The difference of the softening finish temperature and the softening start temperature would indicate the nature of the width of the softening zone. A schematic diagram for such plot is shown in Fig. 2.

7

A = bend contraction starts,

B = 3 percent contraction from initial bed height,

C = 10 percent contraction from initial bed heigh,

T_s = softening start temperature, and

T_t = softening finish temperature.

FIG. 2 SCHEMATIC DIAGRAM SHOWING THE DILATATION AND CONTRACTION IN INITIAL BED HEIGHT OF THE SAMPLE DURING A SOFTENING TEST

8

(Continued from page 2)

9

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

QUANTITY	UNIT	SYMBOL
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

QUANTITY	UNIT	SYMBOL
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

QUANTITY	UNIT	SYMBOL	DEFINITION
Force	newton	N	$1 \quad N = 1 \text{ kg.m/s}^2$
Energy	joule	J	$1 \quad J = 1 \text{ N.m}$
Power	watt	W	$1 \quad W = 1 \text{ J/s}$
Flux	weber	Wb	$1 \quad Wb = 1 \text{ V.s}$
Flux density	tesla	T	$1 \quad T = 1 \text{ Wb/m}^2$
Frequency	hertz	Hz	$1 \quad Hz = 1 \text{ c/s } (s^{-1})$
Electric conductance	siemens	S	$1 \quad S = 1 \text{ A/V}$
Electromotive force	volt	V	$1 \quad V = 1 \text{ W/A}$
Pressure, stress	pascal	Pa	$1 \quad Pa = 1 \text{ N/m}^2$

AMENDMENT NO. 1   JUNE 1999
TO
IS 11283 : 1985 METHOD FOR DETERMINATION OF SOFTENING POINT OF IRON OXIDES (IN POWDER FORM); LUMP ORE, SINTER AND PELLETS

(*Page 8, Fig.* 2) — Substitute the following figure for the existing:
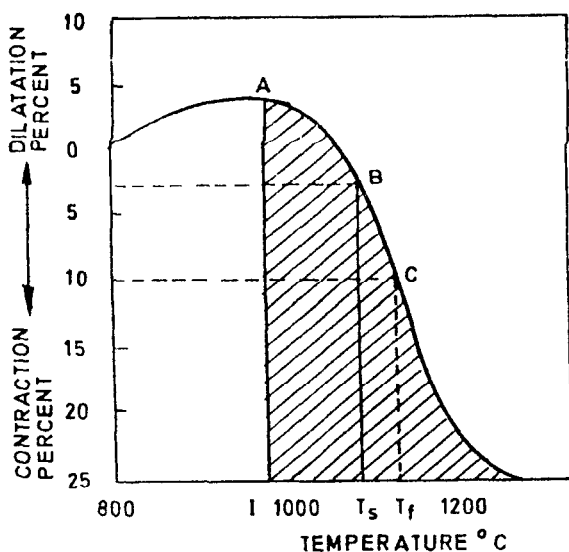
A = bend contraction starts,

B = 3 percent contraction from initial bed height,

C = 10 percent contraction from initial bed height,

T_s = softening start temperature, and

T_f = softening finish temperature.

FIG. 2 SCHEMATIC DIAGRAM SHOWING THE DILATATION AND CONTRACTION IN INITIAL BED HEIGHT OF THE SAMPLE DURING A SOFTENING TEST

(MTD 13)